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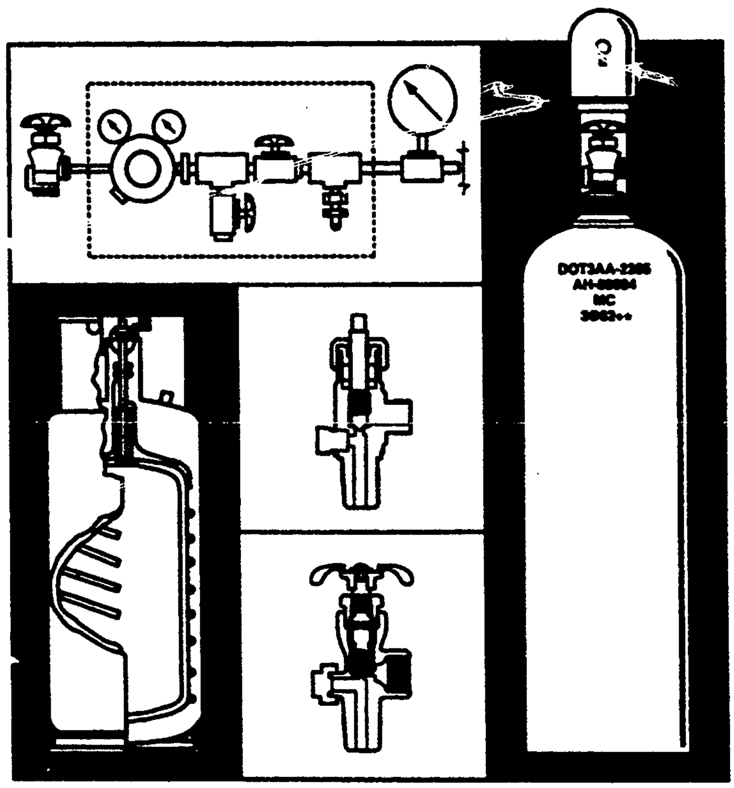
C.1

Pressure Safety Orientation



Los Alamos
NATIONAL LABORATORY

Course Number: 769

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tructional Design: George Glass
hnical Advice: Philbert R. Romero
ng: Susan Basquin
r Design: Rosalie Ott and Denise Derkacs
ations: Jim Mahan
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Contents

Introduction

Course Overview

Pressure Safety Orientation is required for all Los Alamos National Laboratory personnel who work on or near pressure systems and are exposed to pressure-related hazards. This includes pressure-system engineers, designers, fabricators, installers, operators, inspectors, maintainers, and others who work with pressurized fluids and may be exposed to pressure-related hazards.

This course includes introductory information on the following topics:

- the Laboratory Pressure Safety Program,
- pressure-related hazards and accidents, and
- pressure system safety.

Course Objectives

When you have completed this course, you will be able to

- recognize that gas compressed above atmospheric pressure can be a significant source of energy and must be handled carefully,
- list the major components of the Laboratory Pressure Safety Program,
- describe pressure-related accidents and lessons learned, and
- recognize basic pressure system safety features.

Notes . . .

Module 1: Laboratory Pressure Safety Program

Module Overview

To help protect workers and others from pressure-related hazards, the Laboratory has instituted a pressure safety program designed to increase your awareness of and mitigate such hazards.

Module Objectives

When you have completed this module, you will be able to

- list training requirements for pressure-system workers;
- identify pressure-related codes, standards, regulations, and Laboratory requirements; and
- identify Laboratory pressure safety resources and supports.

Pressure Safety Training Requirements

At the Laboratory, all pressure systems must be designed, installed, tested, inspected, maintained, and operated by trained and qualified personnel.

Line managers are responsible for ensuring that their workers are trained and qualified. However, if you feel you are not sufficiently prepared for a particular job, you should request further training before you begin the work.

Other safety courses are required if they apply to your job. These include

- *Gas Cylinder Safety,*
- *Intermediate- and High-Pressure Safety,*
- *Cryogen Safety,* and
- *Hydrogen Gas Safety (Self-Study).*

Pressure Safety Documents

Many hazardous operations require the use of clear, written hazard control plans (HCPs) or special work permits (SWPs). These help ensure that all safety precautions are taken. They also support a continuing "institutional memory" of safety precautions as personnel come and go. Laboratory pressure safety documents are based on a variety of pressure-related codes, standards, and regulations.

Safety Codes, Standards, and Regulations

All pressure systems must be designed, installed, tested, inspected, maintained, and operated in compliance with national codes and consensus standards, including

- American Society of Mechanical Engineers (ASME) *Boiler and Pressure Vessel Code*;
- American National Standards Institute (ANSI)/ASME *Pressure Piping Code*;
- *Matheson Gas Data Book*;
- Compressed Gas Association (CGA) handbook and pamphlets;
- *National Fire Codes and Standards*;
- Title 29, *Labor*, Code of Federal Regulations, Part 1910 (29 CFR 1910);
- Title 49, *Transportation*, Code of Federal Regulations, Parts 106–180 (49 CFR 106–180);
- *Uniform Fire Code*;
- *Uniform Building Code*; and
- federal and state environmental regulations.

Pressure Safety Documents—continued

Laboratory Pressure Safety Program Documents

The Laboratory interprets these codes and standards and provides guidance for safety compliance. These interpretations are located online in Laboratory Implementation Requirements (LIRs) and Laboratory Implementation Guidelines (LIGs). They include

- LIR402-510-01, *Chemical Management*;
- LIR402-1200-01.0, *Pressure, Vacuum, and Cryogenic Systems;*
- LIR402-580-01.0, *Cryogenic Fluids or Cryogens*;
- LIG402-1200-01, *Compressed Gases*;
- LIG402-1200-03, *Gaseous and Liquid Hydrogen*; and
- LIG402-1200-02, *Inspection and Testing of Pressure Systems.*

Pressure Safety Program Assistance

Various groups at the Laboratory are part of the pressure safety program and can help with many phases of pressurized work.

Pressure Safety Issue	Group	Phone Number
Operational controls	Industrial Hygiene and Safety Group (ESH-5)	7-4644
Toxicity and ventilation	ESH-5	7-5231
System design	Project Management Division Office (PM-DO)	5-0000
Operation, maintenance, and testing	Facilities Operations, Maintenance, and Modification Group (FWO-FE)	7-4657
Fire-protection standards	Fire Protection Group (FWO-FIRE)	7-9045
Pressure-gauge calibration	Standards and Calibration Group (ESA-MT)	7-4864
Gas-facility safety	Materials Management Group (BUS-4)	7-4406
Risk analysis	Facility Risk Management Group (ESH-3)	7-3363
Training	Environment, Safety, and Health Training Group (ESH-13)	7-0059

Pressure Safety Program Assistance—continued

Two pressure safety committees at the Laboratory offer help with review and guidance.

Committee	Services
Cryogen and Liquefied Gas Safety Committee (CLGSC)	• Reviews pressure safety program documents. • Distributes information. • Assists with hazard assessments, HCPs, and SWPs. • Reviews operations, systems, and the safety of cryogenic Dewars. For information on the CLGSC, call 7-4240.
Pressure Vessel and Piping Committee (PVPC)	• Reviews designs. • Advises and consults. • Prescribes Laboratory-wide safeguards. • Reviews noncode designs. • Reviews vacuum vessels. For information on the PVPC, call 5-8503.

Lessons Learned: Dewar Explosion

Scenario

In December 1992, researchers at the Laboratory were using small quantities of liquid nitrogen to cool a neutron detector. To avoid having to repeatedly return to work during the winter holidays, they improvised a delivery system to automatically cool the equipment from a larger Dewar. Their homemade system included an inverted Dewar to deliver the liquid. An inadequate vent line passed the liquid nitrogen through to the atmosphere. The Dewar was connected to the detector equipment with noncryogenic valves and was capped with a heat-conducting cap before being inverted. No extra relief valve or rupture disc was included in the system.

After filling, the Dewar began to pop like a coffee percolator, and streams of liquid vented from the detector relief valve. Approximately three minutes after the office was vacated, the Dewar exploded, causing extensive damage to the room. A motion detector located nearby was jarred, which registered the explosion and initiated a search. A window was blown out, the ceiling and walls were damaged, and scientific equipment in the room was damaged.

Fortunately, the Dewar failed at approximately 500 pounds per square inch (psi). Confined boiling liquid nitrogen can reach pressures as high as 43,000 psi—a level of energy that can cause mass destruction and fatalities.

Causes

Investigators determined that the immediate cause of the accident was an obstruction in the vent line, caused either because a cap screw was threaded into it or because an ice plug formed in it. Pressure buildup with inadequate pressure relief caused the inner wall of the Dewar to fail. When the fluid reached the warm outer wall, it quickly began to boil, creating pressure that caused the outer vessel to explode.

Investigators determined that this system had not been reviewed independently for safety and reliability, a violation of administrative requirements. They also found that the workers lacked adequate awareness of the properties and hazards of cryogens and adequate training and experience in the design of such systems.

Lessons Learned: Dewar Explosion—continued

Corrective Actions

The disregard of adminstrative requirements for proper engineering review prompted a call for strict adherence to the pressure protocols in LIR402-580-01.0.

Future operations and any changes to existing procedures were to be thoroughly reviewed by appropriate organizations. Training plans, including on-the-job training, were improved to provide better-qualified personnel. Workers and supervisors were reminded of their training responsibilities. HCPs were written for the use of liquid nitrogen. Requirements for yearly safety inspections and daily walkdowns by the area supervisor were reinforced. Training plans, which include on-the-job training, were revised, and workers and supervisors were reminded of their training responsibilities.

Notes . . .

Module 2: Pressure-Related Hazards and Accidents

Module Overview

Pressure systems can be the source of serious accidents, some resulting from the characteristics of the pressurized contents, others from pressure-related impacts on the system or its surroundings. Recognizing the major causes and types of pressure-related accidents and their possible outcomes underscores the importance of safe work practices in preventing such accidents.

Module Objectives

When you have completed this module, you will be able to

- recognize hazards associated with pressurized fluids,
- describe the causes of pressure-related accidents, and
- recognize the importance of safety while working with pressurized systems and containers.

Hazards Associated with Pressurized Fluids

Pressurized gases and liquids pose various hazards that can result in personal injury and property damage. Your familiarity with these hazards will help you to control them. You may encounter any of the following general hazards when you work on or around pressure systems:

Mechanical failure—Gas cylinders at the Laboratory are generally filled to around 2100 pounds per square inch gauge (psig). Under such high pressure, damaged or mishandled cylinders can fracture violently.

For example, dropping or overheating a pressurized cylinder can cause a fracture and a sudden release of the cylinder's contents. Other mishandled or poorly designed cryogenic and pressure vessels and their fittings can also fracture or become airborne.

Whipping injuries—If not secured properly, broken gas lines and hoses can cause severe whipping injuries.

Hazards Associated with Pressurized Fluids—continued

Injection hazards—Pressurized fluid leaking from a small opening at high velocity can penetrate the skin and cause internal damage.

Oxygen-deficient atmosphere—When a compressed inert gas or any otherwise-harmless gas escapes from its container, it may displace oxygen in the air to dangerous levels, putting workers at risk of asphyxiation. This situation can be especially hazardous in small, enclosed work areas, such as trailers.

Reactivity hazards—Some gases are toxic, corrosive, or flammable and require special handling. For example,

- fluorine, which is potentially fatal if inhaled, can corrode many systems materials;
- oxygen, although not inherently flammable, will make flammable objects ignite more easily and burn much more intensely; and
- aluminum burns hotly in the presence of pure oxygen.

Cryogen hazards—When used improperly or because of unforeseen problems, a cryogenic system can develop very high pressures. Thus, cryogenic systems must be equipped with pressure-relief devices to prevent dangerous levels of pressure buildup in all portions of the system where

- liquid cryogens are present,
- cryogen boil-off gases could be trapped, or
- air could condense and become trapped.

Cryogenic materials are extremely cold and can cause injuries similar to burns. Cryogens can also expand greatly as they warm to room temperature, creating hazards related to energy release and oxygen deficiency.

Causes of Pressure-Related Accidents

Pressure-related accidents often result from one of three general causes:

- failure to consider and control hazards,
- failure to identify hazards during the work process, or
- failure to follow safe work practices.

More specifically, pressure-related accidents usually stem from

- poor design in terms of
  — control and safety devices,
  — material strengths, or
  — material compatibilty;
- faulty component manufacture;
- faulty assembly and/or installation;
- poor maintenance; or
- poor operating procedures, including failure to follow HCPs.

Lessons Learned: Glove Box Overpressurization

Scenarios

As part of their design, glove boxes are often supplied with a constant flow of gas, such as argon, nitrogen, oxygen, compressed air, or instrument air. Engineers at the Savannah River Site determined through a hazard analysis that an accident scenario involving a breached glove box would occur should both the flow regulator (on a 2640-psig supply of compressed gas) and the pressure-relief device fail simultaneously.

The normal inlet and exhaust flow rates that these glove boxes can handle is about 40 standard cubic feet per minute (scfm). Engineers determined that a failed flow regulator would result in an unimpeded flow rate as high as 923 scfm. Such a dramatic increase would certainly result in an overpressurization. Without a working pressure-relief device, pressure buildup in the glove box would breach the glass or plastic enclosure and disperse radioactive material into the surroundings.

A review by the Savannah River staff of past occurrences showed that glove boxes have been overpressurized, resulting in ruptured windows. This has occurred at Oak Ridge National Laboratory during fire-system tests using a 35-psig compressed-gas supply of argon. At Los Alamos National Laboratory in July 1994, a glove box was overpressurized in the plutonium processing facility. The resulting failure of the glass window resulted in the contamination of two persons.

Causes

The Oak Ridge occurrences were the result of pressurized argon being injected into a glove box that lacked adequate pressure-relief components.

The Los Alamos occurrence was traced to a closed butterfly valve, combined with the effects of having doors closed on nearby glove boxes. This combination effectively reduced the glove box exhaust capacity to zero and led to overpressurization.

Questions

1. What could have been done to prevent the Oak Ridge occurrences?

2. What could have been done to prevent the Los Alamos occurrence?

Lessons Learned: Glove Box Overpressurization—continued

Corrective Actions

Facility managers must ensure that compressed-gas sources are identified, analyzed, and controlled. Inlets to glove boxes should have *fixed* restrictors, flow preventors, or pipe-sized reductions built into the lines. Facility managers should ensure that their facility authorization basis includes a hazard analysis for compressed gases or that required engineering controls are used.

Lessons Learned: Tube Trailer Explosion

Scenario

In 1981, workers at the Laboratory were filling hydrogen cylinders from a large, hydrogen-filled tube trailer. A common manifold was used which also connected a tube of oxygen. Only one valve separated these incompatible gases. The valve leaked.

Because the energy required to ignite hydrogen/oxygen mixtures is so low and can even be created by friction, rushing sand particles in the tubing sparked an explosion. Pieces of the tube flew as far as the Los Alamos landfill, approximately 700 yards away. Two workers were injured, and damage to equipment was extensive.

Causes

Investigators determined that the fittings for the hydrogen and oxygen delivery systems were similar, allowing the connection of incompatible gases to the same manifold. In addition, workers were not following procedures and did not understand the serious hazards of mixing hydrogen and oxygen.

Corrective Actions

As a result of the explosion,

- the gas facility's management structure was changed;
- standard operating procedures were rewritten;
- worker training requirements were improved; and
- engineering changes were made, including changing the fittings to make it impossible to mistakenly mix hydrogen and oxygen.

Low-Pressure/High-Volume Systems

The total force of even very low pressure on a large area can create a serious hazard. Failure to consider low-pressure/high-volume hazards can have serious consequences, which may not be readily apparent.

The magnitude of a pressure-related accident is related not only to the pressure level but also to the total stored energy. Large pressurized surfaces—even at very low pressures—can store huge amounts of energy. If released, such energy can explode forcefully, causing severe accidents and injuries.

For example, an overpressure of only 5 psig on a 4-foot-diameter manhole cover on a large tank caused two fatalities when the bolts were removed for routine maintenance.

Module 3: Pressure System Safety

Module Overview

To prevent accidents such as those described in the previous module, pressure-control devices are designed into any system that is pressurized above the ambient pressure. Many pressure systems—whether their energy source is a compressed gas cylinder or a compressor—use safety manifolds, relief devices, and pressure gauges to ensure that each portion of the system operates at safe pressures. Carefully chosen pressure-system components can handle the expected pressures and are compatible with the properties and temperatures of the fluids they contain.

Module Objectives

When you have completed this module, you will be able to

- define basic pressure-system terms,
- recognize safety components built into pressure systems, and
- list safe work practices relating to pressure systems.

Terms and Definitions

The following terms are used in discussing pressure-system safety:

Maximum allowable working pressure (MAWP)—determined by the weakest component of a system or subsystem. The pressure-relief device protecting that part of the system is set to the MAWP.

Maximum operating pressure (MOP)—the actual working pressure, usually 10 to 20% below the MAWP. This lower pressure prevents the pressure-relief device from opening unexpectedly.

Safety factor—the ratio of the component-failure burst pressure to the MAWP. The safety factors are

- at least 4 for systems in occupied areas,
- 3 to 4 for remote systems, and
- under 3 with approval from line management, generally after review by the PVPC.

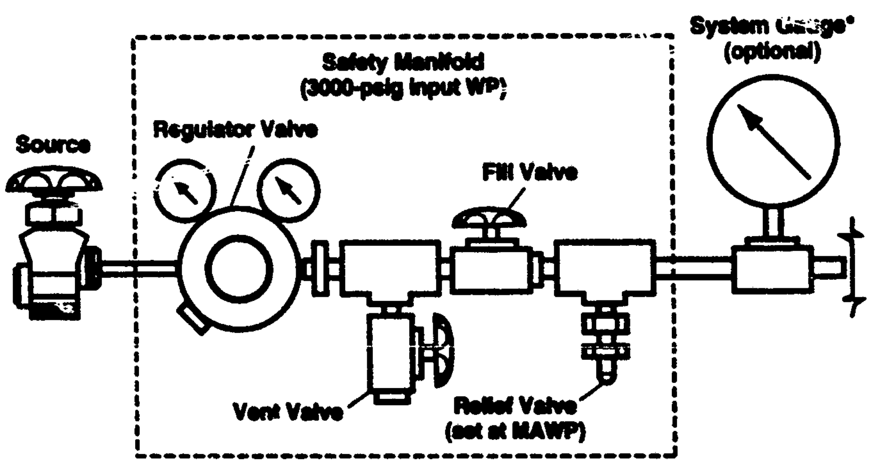
Safety Manifolds

Dead-ended systems are those in which fluids are continuously held under pressure. This is different, for example, from an open-ended system, such as an acetylene torch, in which pressurized gases flow directly into the open atmosphere.

Many dead-ended pressure systems at the Laboratory are supplied by compressed gas. All dead-ended systems require a safety manifold to control the source gas from its entry point to its end use. Safety manifolds

- regulate delivery pressure,
- protect from overpressurization,
- indicate pressure level,
- vent unused pressurized gas, and
- meter end-use pressure.

The basic components of a safety-manifold system are shown in the diagram below.



*If a test gauge of over 4 inches in diameter is required, it must be of the "safety type" with blowout back and securely attached plastic face. The scale should read about double the system pressure, but never less than 1.2 times the maximum system pressure.

Safety-Manifold System

Regulators

Regulators are devices that control the pressure of the system contents. Regulators reduce pressure; they do not act as positive shutoffs. When they malfunction, gas can creep through them at a slow rate and increase downstream pressure beyond the MAWP. A fill valve should always be used to shut off gas flow completely.

***Note:** Many regulators contain built-in relief devices to protect the regulator. These devices do not protect the system.*

Single-stage regulators are used when constant regulation is not important, as in a building's air system. These regulators provide high flow rates at moderate pressures and allow output pressures to drop as cylinders empty.

Two-stage regulators maintain constant delivery pressures as cylinders empty. These regulators generally allow lower flow rates.

Pressure-Relief Devices

In addition to the pressure-relief devices built into the gas cylinder and the regulator, the pressure system as a whole must also be protected by one or more pressure-relief devices.

Pressure-relief devices for the system must

- be set to below or at the maximum pressure determined by the component with the lowest MAWP,
- provide sufficient flow capacity,
- provide a safe discharge path,
- be placed on all parts of the pressure system that can be isolated, and
- be reset only by authorized workers.

***Note:** All adjustments and other changes to a pressure-relief device must be recorded in a logbook.*

Vent Valves

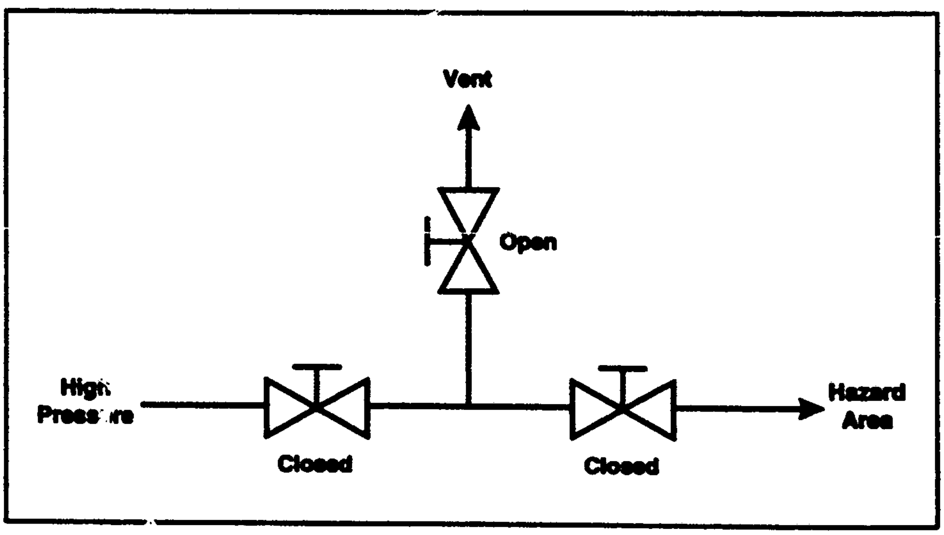
Tightening or adjusting any pressure-system component while it is under pressure places undue strain on the threads and can lead to failure. Opening a threaded connection to release or vent pressure is also unsafe. Therefore, vent valves must be provided to relieve pressure in all parts of the system where pressure can build up.

Depending on the type of gas, vent valves must discharge safely away from personnel, often directly to the outdoors. These discharge paths must be maintained as originally designed.

Double Block and Bleed

All valves can and will eventually leak. Leakage may be due to wear or contamination at the seat; however, even new valves often allow some pressurized gas to seep through. When a hazardous gas must be absolutely shut off from a system, extra precautions must be taken.

In such situations, two shutoff valves are used with a vent valve between them. To close off the gas flow, both shutoff valves are closed and the vent valve is opened. Any gas passing through the first valve escapes safely through the vent valve rather than building up enough pressure to pass through the second shutoff valve.



Double-Block-and-Bleed System

Pressure Gauges

Pressure gauges are often required to provide more accurate system-pressure readings than regulator gauges can provide. Pressure gauges

- are most accurate if graduated to about 2 × MAWP;
- should not be used if they read less than 1.2 × MAWP;
- must be made from materials that are compatible with system contents and pressures;
- must be safety-type gauges if used in high-hazard applications (for example, the gauge must have safety glass and a blowout back);
- should be protected with a snubber against surges or oscillating pressures; and
- should be protected with a pressure-relief device.

Caution: *Never use oil in an oxygen gauge.*

Safe Work Practices

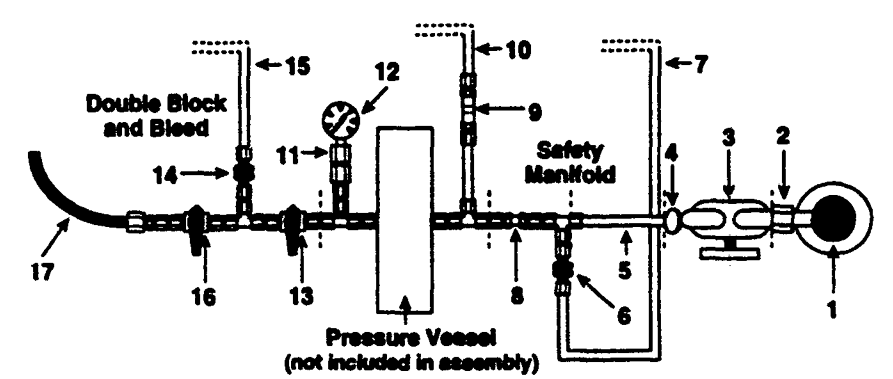
When working on or around pressure systems, you must adhere to safe work practices, including the following:

- Wear safety glasses with side shields, or use a face shield.
- Follow HCP or SWP requirements carefully.
- Use warning signs, and mark or label pressure vessels and systems to identify the operating pressure and contents.
- Restrict access to high-pressure areas.
- Handle, store, and dispose of gas cylinders safely.
- Avoid temperature extremes, which can cause pressure changes and component failure.

Caution: *Never, under any circumstances, work on a pressure system while it is under pressure. Instead, depressurize the system, and use lockout/tagout if appropriate.*

Exercise: Pressure System Assembly

The diagram below shows a top view of a typical pressure system. During this hands-on exercise, you will make three connections of four preassembled subsections of this system.



1 Cylinder
2 CGA Connection
3 Regulator
4 Regulator Fill Valve
5 Down Tube
6 Vent Valve
7 Vent Tube
8 Check Valve
9 Pressure-Relief Device
10 Vent Tube
11 Snubber
12 System Gauge
13 Blocking Valve
14 Vent Valve
15 Vent Tube
16 Blocking Valve
17 Pigtail

Pressure System Assembly

Instructions: To assemble the pressure system, follow these steps. *Note: All connections use Swagelok® fittings, which should first be hand-tightened and then wrench-tightened, using two wrenches, with no more than a one-eighth turn. Avoid cross threading; if the pieces do not fit together easily, notify the instructor.*

1. Connect the down tube (5) to the Tee connected to the vent valve (6), the vent tube (7), and the check valve (8), such that the tube reaches up to where the regulator (3) will attach to the gas cylinder (1).
2. Connect the check-valve end of the system to the Tee connected to the pressure-relief valve (9) and the snubber (11), which is connected to the system gauge (12). *Note: This second subsection contains a simple copper tube representing the pressure vessel to be served by the safety manifold.*
3. Connect the system-gauge end of the system to the double-block-and-bleed arrangement (13, 14, 16), which is connected to the pigtail (17).

This system is now ready to be connected to a regulator and mounted onto a gas cylinder in the Gas Cylinder Safety course, which is a follow-on to this course.

Exercise: Pressure System Assembly—continued

This system is now ready to be connected to a regulator and mounted onto a gas cylinder in the Gas Cylinder Safety course, which is a follow-on to this course.

Pressure Safety Orientation

Course Objectives

- Recognize that gas compressed above atmospheric pressure can be a significant source of energy and must be handled carefully
- List the major components of the Laboratory Pressure Safety Program
- Describe pressure-related accidents and lessons learned
- Recognize basic pressure systems and their safety features

Module 1 Objectives

- List training requirements for pressure-system workers
- Identify pressure-related codes, standards, regulations, and Laboratory requirements
- Identify Laboratory pressure safety resources and supports

Pressure Safety Training Requirements

Pressure safety training is required for all personnel who work with pressure systems and perform any of these functions

- Design
- Installation
- Testing
- Inspection
- Maintenance
- Operation

Other Pressure Safety Training Available

- Gas Cylinder Safety
- Intermediate- and High-Pressure Safety
- Cryogen Safety
- Hydrogen Gas Safety (Self-Study)

National Safety Codes and Standards

- ASME Boiler and Pressure Vessel Code
- ANSI/ASME Pressure Piping Code
- Matheson Gas Data Book
- CGA handbook and pamphlets
- National Fire Codes and Standards
- 29 CFR 1910
- 49 CFR 106–180
- Uniform Fire Code
- Uniform Building Code
- Federal and state environmental regulations

Laboratory Pressure Safety Program Documents

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- LIR402-1200-01, Pressure, Vacuum, and Cryogenic Systems
- LIR402-580-01, Cryogenic Fluids or Cryogens
- LIG402-1200-01, Compressed Gases
- LIG402-1200-03, Gaseous and Liquid Hydrogen
- LIG402-1200-02, Inspection and Testing of Pressure Systems

Pressure Safety Program Assistance

Pressure Safety Issue	Group	Phone Number
Operational controls	ESH-5	7-4644
Toxicity and ventilation	ESH-5	7-5231
System design	PM-DO	5-0080
Operation, maintenance, & testing	FWO-FE	7-4987
Fire-protection standards	FWO-FIRE	7-6045
Pressure-gauge calibration	ESA-MT	7-4964
Gas-facility safety	BUS-4	7-4486
Risk analysis	ESH-3	7-3363
Training	ESH-13	7-0069

Pressure Safety Committees

Committee	Services
Cryogenic and Liquefied Gas Safety Committee (CLGSC)	• Reviews pressure safety program documents. • Distributes information. • Assists with hazard assessments, HCPs, and SWPs. • Reviews operations, systems, and the safety of cryogenic Dewars. For information on the CLGSC, call 7-4240.
Pressure Vessel and Piping Committee (PVPC)	• Reviews designs. • Advises and consults. • Prescribes Laboratory-wide safeguards. • Reviews noncode designs. • Reviews vacuum vessels. For information on the PVPC, call 5-8883

Liquid Nitrogen Dewar Explosion

Use and Setup

- Used to cool nuclear detector
- Inverted Dewar with U-tube vent
- Inadequate control of pressure to start flow
- Vent line modified to build up pressure
- No extra relief valve

Incident

- Pressure rose above 800 psi
- Exploded 3 minutes after evac

Cause

- Vent line obstructed; intentionally?
- No pressure relief valve
- Lack of sufficient knowledge
- Did not apply ISM
- Did not use Lab resources

Corrective Action

- Adhere to LIRs
- SOPs written for LN2
- Training
- Inspections and walkdowns

Module 2 Objectives

- Recognize hazards associated with pressurized fluids
- Describe the causes of pressure-related accidents
- Recognize the importance of safety while working with pressurized systems and containers

Hazards Associated with Pressurized Fluids

- Mechanical failure—Under high pressure, damaged or mishandled pressure vessels can fracture violently.
- Whipping injuries—Unsecured lines and hoses can lash through objects and cause severe bodily harm.
- Injection hazards—Pressurized fluid leaking from a small opening at high velocity can penetrate the skin and cause internal damage.

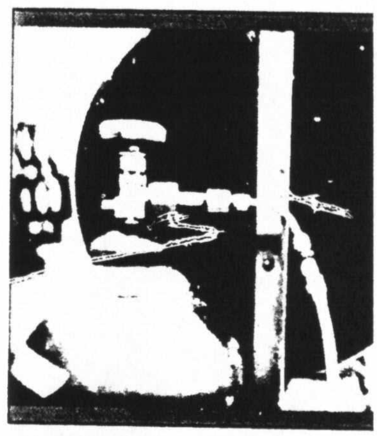
Hazards Associated with Pressurized Fluids (cont.)

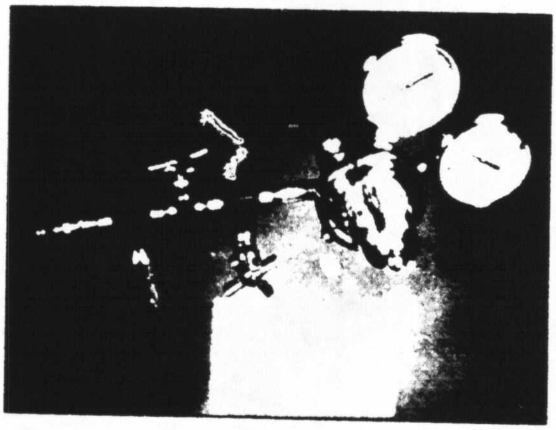
- Oxygen-deficient atmosphere - Many gases can displace breathable oxygen
- Reactivity hazards - Some gases are toxic, corrosive or flammable
- Cryogen hazards - Cryogenic vessels can release immense energy. Cryogens can cause cold burns

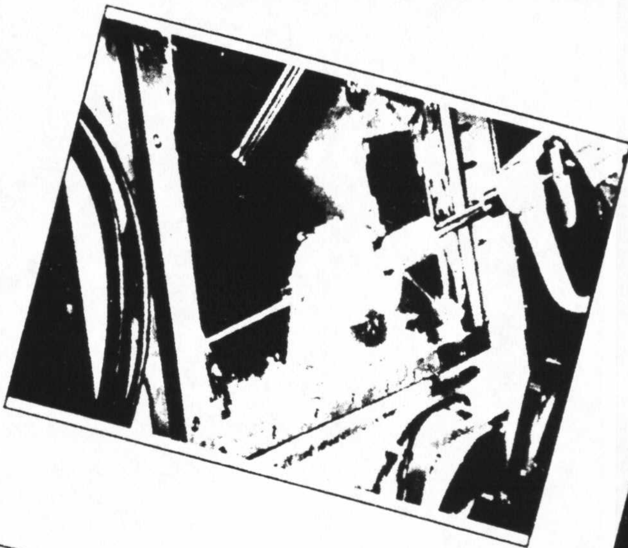
General Causes of Pressure-Rel

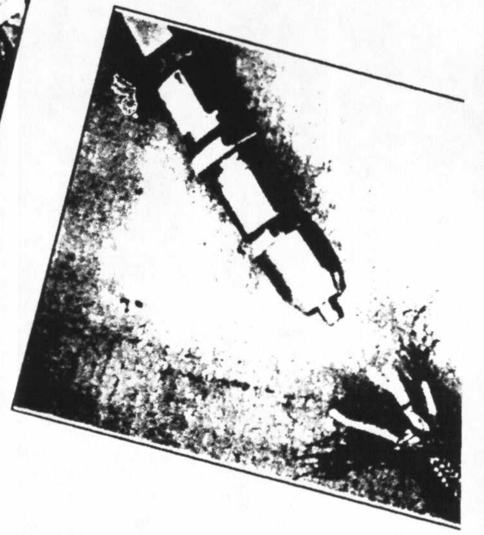
- Failure to identify and consider haz work process
- Failure to establish control of hazar
- Failure to follow safe work practices

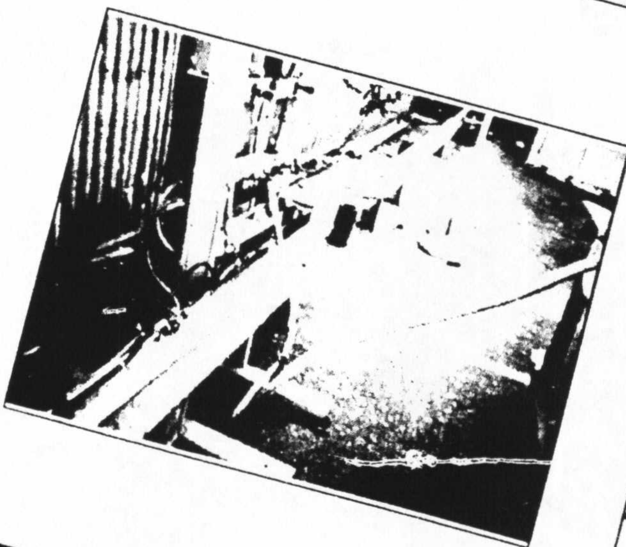
SLIDE SHOW

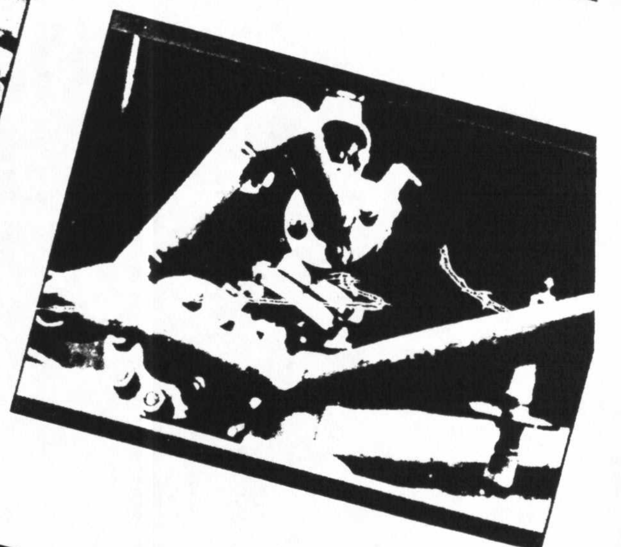


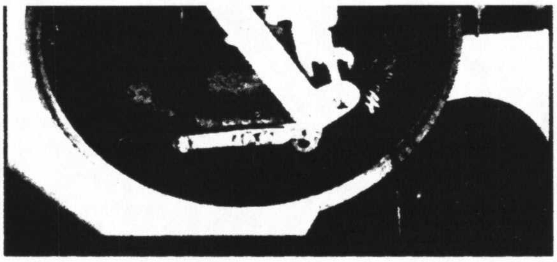


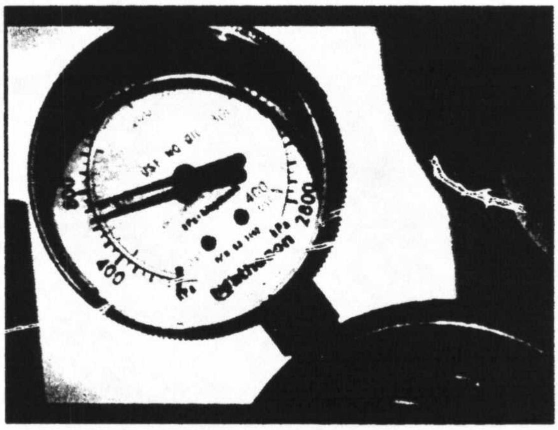


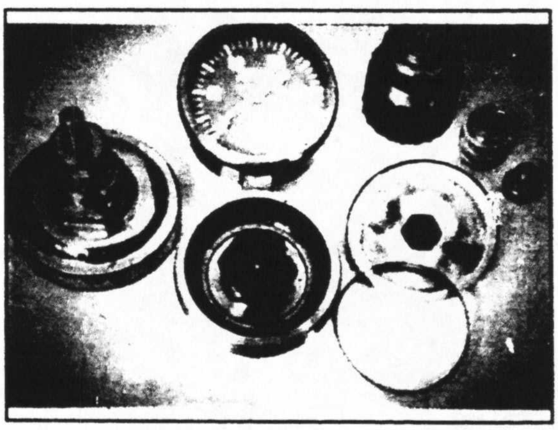


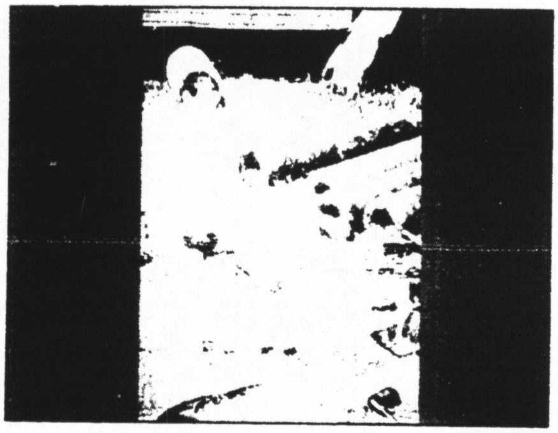


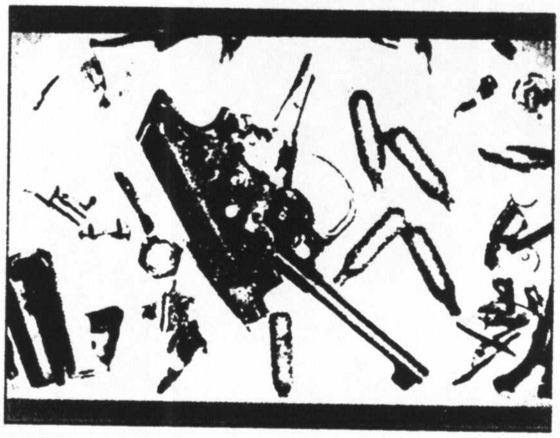


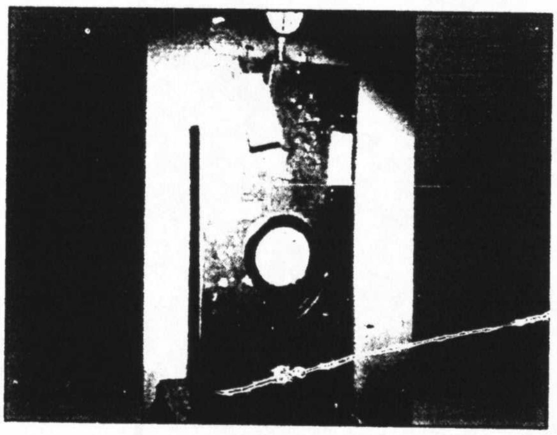


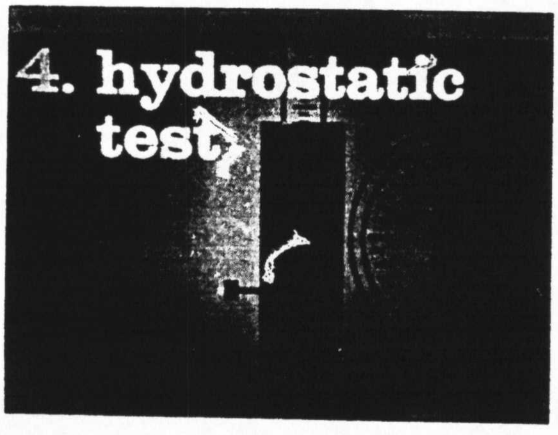


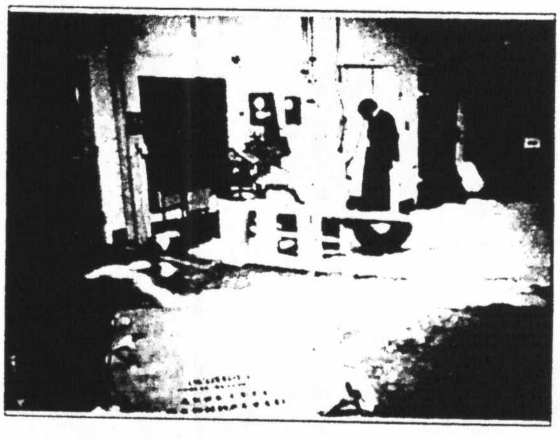


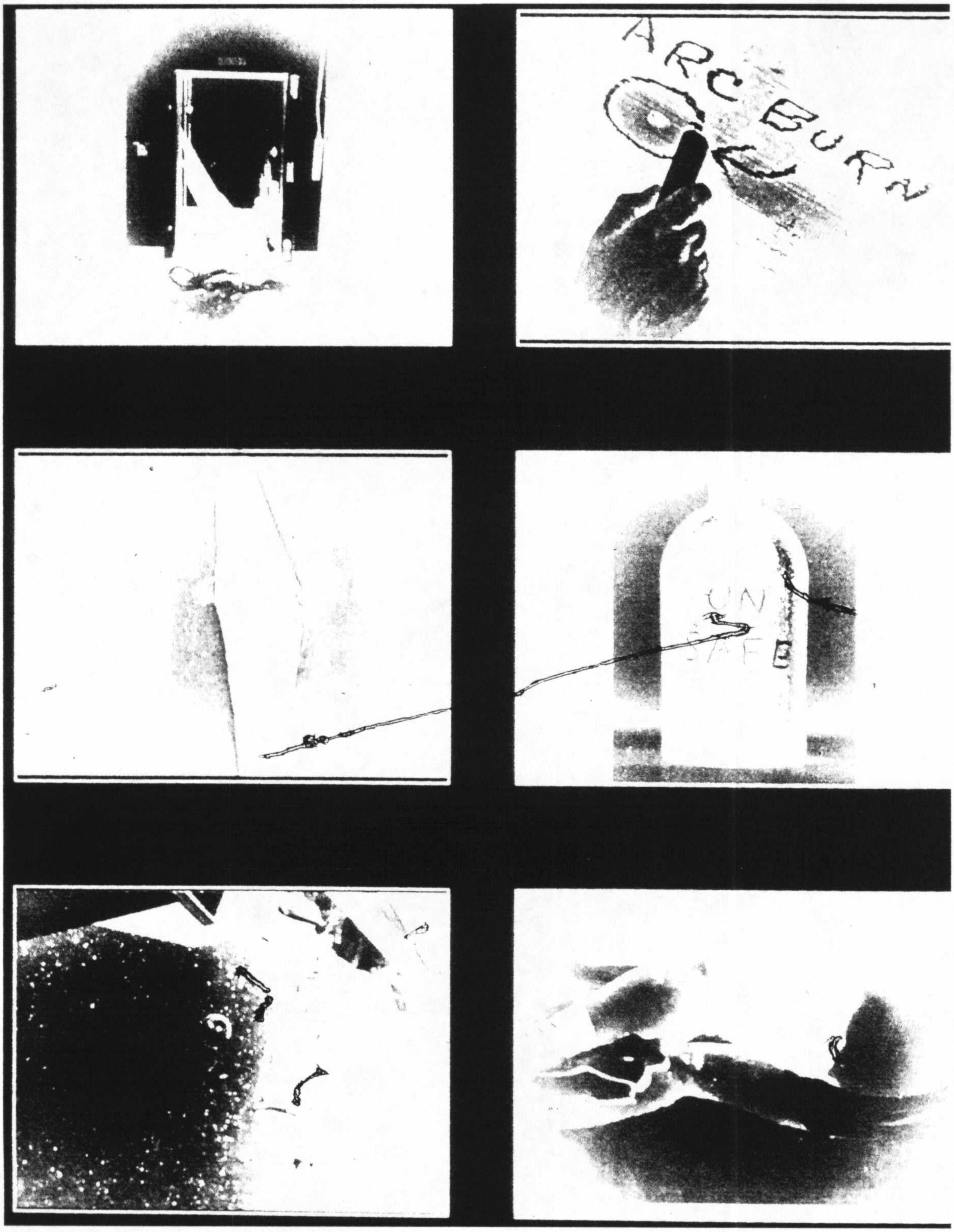







4. hydrostatic
test

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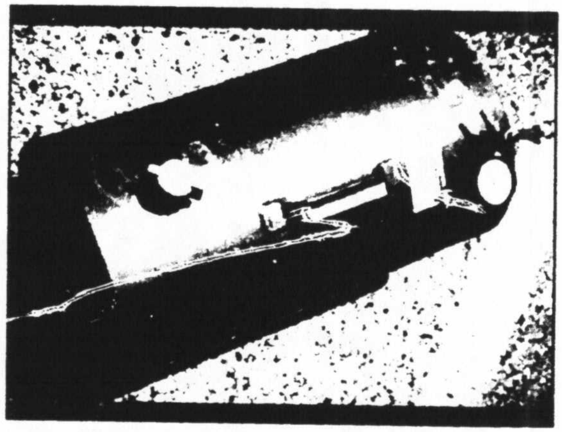
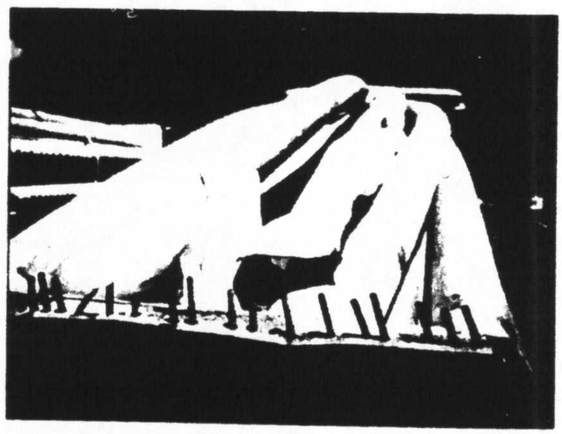
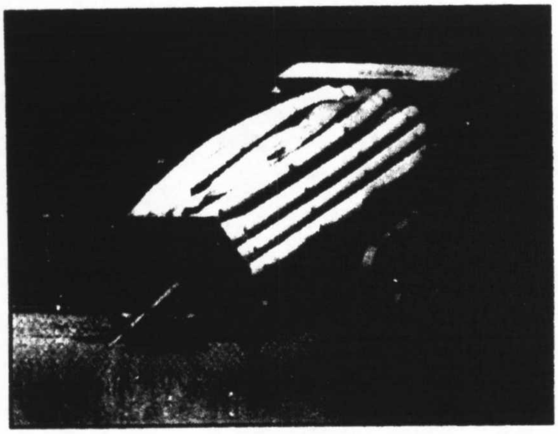
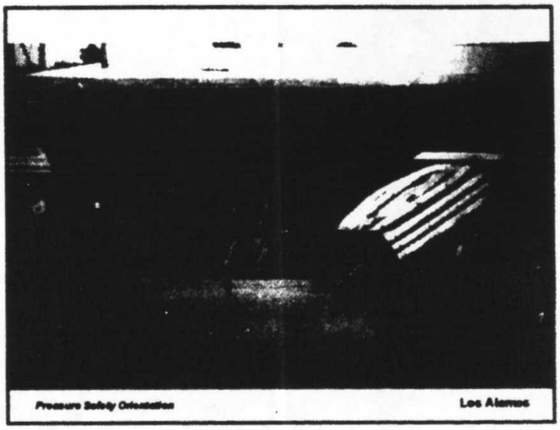
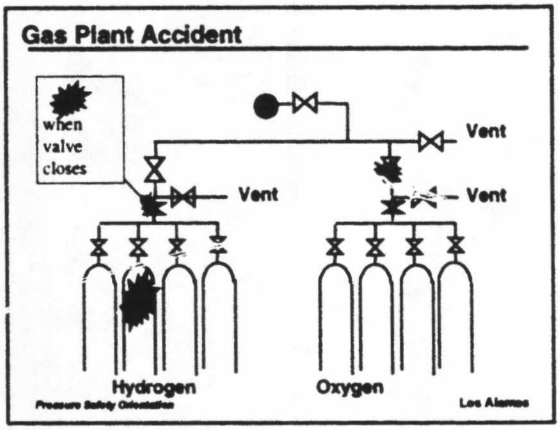
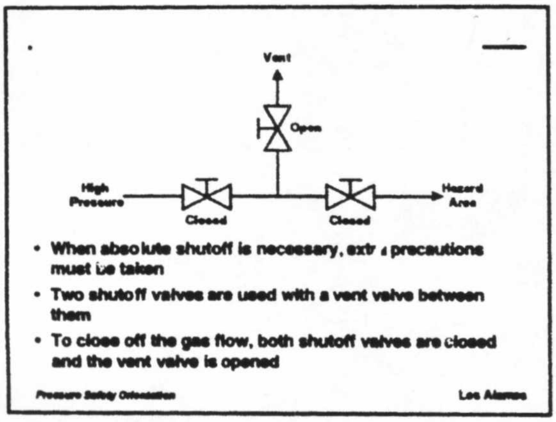












Specific Causes of Pressure-Related Accidents

- Poor design in terms of
  - Control and safety devices
  - Material strengths
  - Material compatibility
- Faulty component manufacture
- Faulty assembly and/or installation
- Poor maintenance
- Poor operating procedures

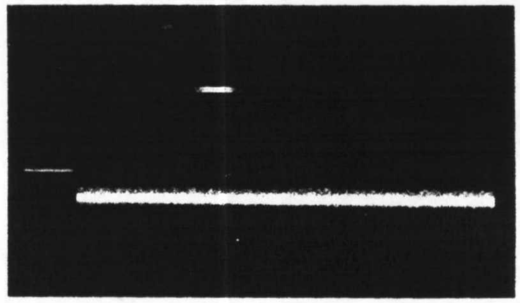
Pressure Safety Orientation — Los Alamos

Low-Pressure/High-Volume Systems

- Even very low pressures on a large area can amount to tremendous levels of energy
- The magnitude of a pressure-related accident relates to the total stored energy
- A 5-psig overpressure on a 4-foot-diameter manhole cover on a large tank caused two fatalities

Pressure Safety Orientation Los Alamos

LOW PRESSURE ACCIDENT



Pressure Safety Orientation Los Alamos

Module 3 Objectives

- Define basic pressure-system terms
- Recognize safety components built into pressure systems
- List safe work practices relating to pressure systems

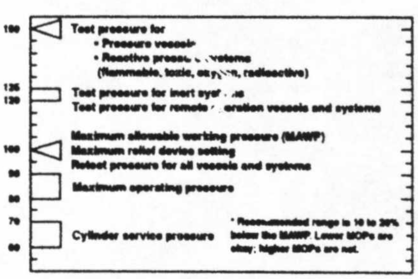
Pressure Safety Orientation Los Alamos

Terms and Definitions

- Maximum allowable working pressure (MAWP)
  - Determined by the weakest component
  - Determines the pressure-relief device setting
- Maximum operating pressure (MOP)
  - Actual working pressure, usually 10 to 20% below the MAWP
  - Prevents the pressure-relief device from opening unexpectedly
- Safety Factor
  - Ratio of the component-failure burst pressure to the MAWP
  - At least 4 in occupied areas; 3 to 4 in remote areas; under 3 with special approval

Pressure Safety Orientation Los Alamos

Pressure Levels



Source: DOE Pressure Safety Manual

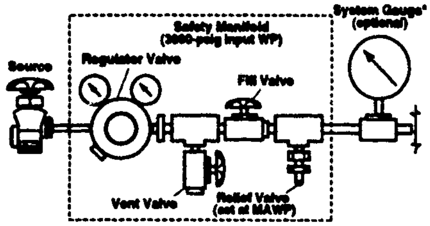
Pressure Safety Orientation Los Alamos

Safety Manifolds

- Regulate delivery pressure
- Protect from overpressurization
- Indicate pressure level
- Vent unused pressurized gas
- Meter end-use pressure

Pressure Safety Orientation Los Alamos

Safety-Manifold System



*If a test gauge of over 4 inches in diameter is required, it must be of the "safety type" with blowout back and securely attached plastic face. The scale should read about double the system pressure, but never less than 1.2 times the maximum system pressure.

Regulators

- Reduce pressure
- Maintain pressure at a set value
- In conjunction with aperture sizes, determine the flow of pressurized contents through systems
- Can not assure positive shutoff

Regulators (cont.)

- Single-stage regulators
  - —are used when constant regulation is not needed or input pressure is kept constant;
  - —provide high flow rates at moderate pressures;
  - —let output pressure vary with the input pressure.
- Two-stage regulators
  - —generally are limited to lower flow rates;
  - —maintain constant delivery pressures over large range of input pressure.

System Pressure-Relief Devices

- Set to below or at the maximum pressure determined by the component with the lowest MAWP
- Provide sufficient flow capacity
- Provide a safe discharge path
- Placed on all parts of the pressure system that can be isolated
- Reset only by authorized workers

Vent Valves

- Relieve pressure in all parts of the system where pressure can build up
- Must discharge safely away from personnel, often directly to the outdoors.
- Discharge paths that are changed must be assured to avoid harmful contact with personnel.

Pressure Gauges

- Provide system-pressure readings
- Most accurate if graduated to about 2 x MAWP
- Should not be used if they read less than 1.2 x MAWP
- Must be made from materials that are compatible with system contents and pressures
- Must be safety-type gauges if used in high-hazard applications
- Should be protected with a snubber against surges or oscillating pressures
- Should be protected with a pressure-relief device

Safe Work Practices

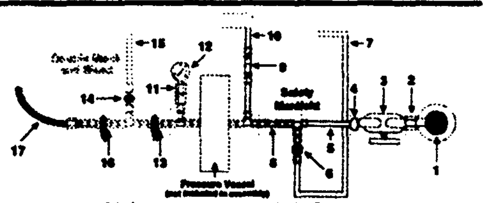
- Wear safety glasses with side shields; use a face shield also for high hazard setups.
- Follow HCP or SWP requirements carefully.
- Use warning signs and label pressure vessels and systems to identify operating pressure and contents.
- Restrict access to high-pressure areas.
- Avoid temperature extremes.
- Handle, store, and dispose of gas cylinders safely.
- Never use a body part to test for pressure.
- Never work on a system while it is under pressure.

TIGHTENING THE SWAGELOK® FITTINGS

- Hand tighten after carefully aligning the threads of the nut onto the body.
- Wrench tighten with two wrenches (backup wrench on body) about one-eighth of a turn.

Note: These instructions apply only to this classroom activity. Notice #8851 requires a gauged assembly for compression fittings. Because these fittings have been reassembled many times, the use of a gauge is precluded by the resultant diminished nut and body spacing required for a leak-tight seal.

Pressure System Assembly



1. Cylinder
2. CGA Connection
3. Regulator
4. Regulator Fill Valve
5. [illegible]
6. Vent Valve
7. Vent Tube
8. Check Valve
9. Pressure-Relief Device
10. Vent Tube
11. Snubber
12. System Gauge
13. Blocking Valve
14. Vent Valve
15. Vent Tube
16. Blocking Valve
17. Pigtail